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VETERINARY SURGERY 44(6), 2015, 751-755
DOI: 10.1111/vsu.12336

In-vitro evaluation of skin staples for typhlotomy closure in cattle

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Abstract

Objective: To compare three techniques for typhlotomy closure in bovines.

Study Design: Ex-vivo study

Sample Population: Bovine fresh cadaveric caeca (n=18).

Methods: Typhlotomies (4 cm in length) were made and closed with one of the following three techniques: hand-sewn, two-layer suture consisting of a continuous, full-thickness layer oversewn with a Cushing layer (Group C); hand-sewn, double inverting suture consisting of a first Cushing layer oversewn with an additional Cushing layer (Group CDI); skin staples (Group SKS). Closure time, bursting pressure and related costs of each technique were calculated and compared.

Results: Both hand-sewn techniques were more time-consuming than skin staples. Inter-group differences in terms of bursting pressure did not reach statistical significance.

Conclusion: Hand-sewn techniques are effective but fairly demanding in terms of time and skills. Skin staples are less time-consuming, and bursting pressure is markedly over intraluminal pressure during bowel distension. For this reason, a SKS technique is a valid option for typhlotomy closure in cattle.

Introduction

A surgical approach to caecal disorders is not uncommon. Typhlotomies can be easily performed during field surgery in cattle,[1] usually following distension or torsion of the caecum to permit its emptying . The standard method of closure is a two-layer suture pattern.[2] This can be an appositional and inverting suture pattern or a double inverting suture pattern, both of which make high demands on the surgeon's time and skills.[1]

Three approaches to typhlotomy closure in cattle have been described, involving either surgical staplers [2] or, more commonly, hand-sewn techniques with a two-layer closure.[1-3] Optimal results have been obtained with intestinal stapler devices (TA90), but these are very expensive and cannot be widely used in farm animal surgery[4] . Two-layer suture patterns, on the other hand, are affordable but unproductive time-wise. Use of skin staplers for intestinal anastomoses or enterotomies has been described in humans and also in pigs, dogs and horses.[5-9] Our hypothesis is that they may provide an effective, fast and inexpensive tool for typhlotomy closure in cattle.

The aim of this study is to compare three techniques of closing typhlotomies – using skin staples, a double inverting layer suture (Cushing oversewn with Cushing) and a two-layer suture (simple continuous full-thickness layer oversewn with a Cushing suture), respectively – in terms of time, bursting pressure and cost.

Materials and Methods

18 caecum specimens were collected from 18 slaughtered bovines (males, median age: 18 months, median weight: 530 Kgs). Specimens were harvested immediately after death, transported and stored at room temperature in 0.9% saline solution.

The 18 intestinal samples were randomly assigned to three different groups, comprising 6 samples each. Randomisation was performed with a random number generator (www.random.org). All specimens were tested within 4 hours of death.

Surgical technique

With the aid of a scalpel, a 4 cm typhlotomy was made by longitudinally incising the caecal apex,[1] using a ruler to standardise the incision. In Group C, typhlotomies were closed with a two-layer suture consisting of a first, full-thickness, continuous pattern followed by a Cushing pattern,[4] in Group CDI, a double Cushing suture [1] was used, while in Group SKS closure was performed with skin staples (Weck Visistat 35R, staple size 5.7 x 3.9 mm).[9,10] In groups C and CDI, USP 2-0 Glycomer 631, (Byosin®, Covidien) was used for suturing. For the SKS technique, we used a curved mosquito and Allis forceps aiming at a mild tissue inversion of the intestinal edges (Fig. 1). Inversion was obtained by placing the mosquito forceps just proximally to the incision and gently pushing the tissue, which was then gripped with Allis forceps. The first staple was inserted distal to the Allis forceps, so that it would be centred on the wound. A number of staples were then applied distally, placing the tip of the staples in contact with the previous staple before firing.

Construction Time

The time to complete each typhlotomy was recorded. For the stapled technique, the time was started when the mosquito forceps was placed, and stopped when the Allis forceps was removed, after placing the last staple. For the handsewn techniques, the time was started right after the first needle insertion and stopped when the suture was cut.

Leak test

All typhlotomies were leak-tested by air filling and immersion in a water tank. After the suture was completed, each specimen was closed with a self-locking plastic band placed approximately 15 cm proximal to the enterotomy site. Specimens were then slightly inflated with air and immediately soaked in water. In the event of leakage, single stitches/staples would be added at the leaking point.[9] Leakage was identified by bubbles exiting the suture.

Bursting Pressure

Bursting strength was tested using a modified gas inflation tank test.[9,10] Briefly, a metal cannula connected to a mercury manometer was inserted at one end of the specimen. A needle, connected to a compressed air tank, was tunnelled into the caecal wall away from the enterotomy. The entire specimen was soaked in water and inflated with air at 1L/min, until gas leakage or bursting occurred. Luminal pressure was measured continuously by means of the manometer and then recorded. Failure was confirmed by the presence of gas bubbles leaking from the caecum, and by a stop/drop in luminal pressure.[10]

Statistical analysis

Data were tested for normality using the Kolmogornov-Smirnov test and found normally distributed. For this reason, construction times and bursting pressures for all three techniques were compared using ANOVA. All statistical analyses were performed using a commercial statistical software. Significance was set at $p \leq 0.05$.

Results

Macroscopic appearance

Handsewn techniques provided a smooth inverted surface, with little exposed material adjacent to where the initial and final knots had been tied. The shape of the caecum was maintained, with little deformation at the closure site. Skin staples produced an inverted surface, with all staples exposed and moderate deformation at the caecal wall. A mean of 23 staples were used (maximum 27, minimum 21).

Construction Time:

Mean completion time was 1.14± 0.096 min for stapled typhlotomy, 5.79 ± 1.044 min for the handsewn, two-layer technique (Group C), and 4.32 ± 1.114 for the handsewn, double inverting technique (Group CDI). Statistically, the difference was extremely significant ($p < 0.0001$).

Leak Test:

None of the suture lines leaked after completion. Therefore, no more staples of single stitches were added.

Bursting Pressure:

Mean (±SD) bursting pressure was 90.00 ± 15.83 mmHg for stapled typhlotomy (Group SKS), 115.83 ± 45.871 mmHg for the handsewn, two-layer technique (Group C), and 86.66 ± 24.014 mmHg for the handsewn, double inverting technique (Group CDI). The difference was not statistically significant ($p=0.24$).

Discussion

Typhlotomy closure was significantly faster with skin staples than with two-layer sutures. No statistically significant difference was evidenced in the three groups with regard to bursting strength. Recorded bursting strengths for handsewn and stapled techniques were markedly higher than the intraluminal pressures recorded in vivo for bowel distension.[10] During the bursting strength test, none of the suture lines (i.e., neither handsewn nor stapled) failed. Conversely, tissue failure occurred regularly. Some stapled typhlotomies started leaking after distention by pathological pressures. This was not to be ascribed to staple loosening, however, but rather to the formation of serosal tears which ultimately prejudiced bowel integrity.[10] Stapled typhlotomy typically failed at the proximal end of the line, usually at the first staple. Likewise, handsewn typhlotomies (i.e., Group C and Group CDI), typically failed at the first knot. Failure could be due to forces generated by distension and to caecal wall compliance, which could stretch the wall in a proximo-distal direction. Based on our experience, the surgeon needs only grasp the edge of the incision while placing the staples. The amount of surrounding tissue involved should be minimised, otherwise the tissue will tear, with consequent leakage and bursting.

In literature, a number of works discuss closure with a double inverting suture pattern.[1] This method has been reported to be somewhat deficient in terms of bleeding control[9] , although Steiner *et al.* [4] had initially described a two-layer suture that would seem to prevent haemorrhage. As described *supra*, this pattern involves a first, full-thickness layer designed to control bleeding by grasping the mucosa within each needle bite.[9] Haemorrhage control is a crucial factor, that often dictates the choice of suture pattern Skin staples have been evaluated for use in intestinal surgery in horses.[9,10] Like handsewn, one-layer sutures, a stapled technique may not achieve optimal bleeding control. This, undoubtedly, is a major flaw which could nonetheless be remedied by allowing vessels to coagulate, which implies starting to close a little after the incision has been made.[9] Meanwhile, the caecum is emptied from its contents.

As reported by Gandini [9,10] and Steiner [4] in relation to skin stapled enterotomies, staples are left exposed in the abdominal cavity (Fig. 2). Steiner technique, however, led to eversion of the mucosa, thing that is not occurrig with our method. In one of his cases, Steiner, four days after surgery found proliferative granulation tissue with a few foci of necrosis and steatonecrosis.[4] Of note, surgical stainless steel staples are inert and for this reason they have been associated with lower complication rates or better intestinal healing than sutures.[11] Additionally, exposure in the abdominal cavity is reportedly not an issue, because staples normally migrate to the lumen.[8] Skin staples may also reduce bowel handling and diminish the amount of reactive material in the caecal wall, with consequently less inflammation.

Our preliminary testing indicated that regular (5.7 mm x 3.9 mm) staples are suitable for bovines, with better edge approximation and inversion than larger (6.8 mm x 3.9 mm) staples. This is in line with previous studies in horses[9,10] and substantiates Steiner's conclusion that staple size should be "as small as the tissue permits." [4] We found stapled closures easy to learn and perform, with minimal bowel manipulation compared to two-layer, hand-sewn sutures or double inverting sutures. Unlike linear staplers, they also produce an inverted suture line. Placing the tip of the instrument against each previously placed staple can help achieve a standardised inter-staple distance. More importantly, staple devices can be handled without the risk of touching any non-sterile areas, an advantage which may not be factually achievable during field surgery with conventional sutured techniques.

Cost is also an important factor. Skin staples are cheaper than other intestinal stapling devices and can be readily purchased. Their cost is approximately equivalent to sutures. At the time of writing, skin staple devices are priced around 13 euros in Europe, while Biosyn sutures are approximately 7 euros. Skin staples can also be easily removed and replaced, in case the typhlotomy needs to be reopened once or twice during surgery, after the caecum has been refilled. [1]

The main advantages of our method are related to speed of closure and reduced bowel handling as compared to traditional, hand-sewn techniques. Both these factors may be beneficial in reducing post-operative complications. Based on our results, skin staple devices may be used effectively to close bovine typhlotomies. Further in-vivo studies are needed to explore possible complications of this technique.

Competing interests

Authors declare no conflict of interest

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Figure legend

Fig. 1 : Curved mosquito and Allis forceps allow a mild tissue inversion of the intestinal edges

Fig. 2 : Complete stapled tiphlotomy